

## Abstracts of Technical Articles by Bell System Authors

### *Electrochemical Factors in Underground Corrosion of Lead Cable Sheath.*<sup>1</sup>

V. J. ALBANO. Stray current is the principle cause of corrosion failures on underground telephone cables in most cities where trolleys are operated. To mitigate this condition, the cable sheaths are "drained" to the negative return system of the traction system. By this means not only is the stray current anodic area largely eliminated, but the cables automatically become negative to earth, and therefore are cathodically protected. The cathodic protection afforded in this manner prevents other types of corrosion from occurring. With the gradual abandonment of trolley systems, and with the extension of underground cables into non-trolley areas, the percentage of underground telephone plant receiving this protection is decreasing. As a result, the problems of lead corrosion due to such causes as galvanic and local cell action of various types, and chemical action by substances in the soil are becoming more prevalent. It is the purpose of this article to review some of the basic principles of corrosion not involving stray currents, and show how they apply to the problems of lead cable sheath corrosion.

*PCM Equipment.*<sup>2</sup> H. S. BLACK and J. O. EDSON. PCM, pulse code modulation, is a new solution to the problem of overcrowded frequency spectrum. It appears to have exceptional possibilities from the standpoint of freedom from interference, and seems to have inherent advantages over other types of multiplexing.

*Coaxial-Cable Networks.*<sup>3</sup> FRANK A. COWAN. This paper discusses the general features of the coaxial system, its application for both telephone and television, and the future prospects for very-broadband transmission facilities in the communication network.

*Parabolic-Antenna Design for Microwaves.*<sup>4</sup> C. C. CUTLER. This paper is intended to give fundamental relations and design criteria for parabolic radiators at microwave frequencies (i.e., wavelengths between 1 and 10 centimeters). The first part of the paper discusses the properties of the parabola which make it useful as a directional antenna, and the relation of phase polarization and amplitude of primary illumination to the over-all radiation characteristics. In the second part, the characteristics of practical feed systems for parabolic antennas are discussed.

<sup>1</sup> *Corrosion*, October 1947.

<sup>2</sup> *Electrical Engineering*, November 1947.

<sup>3</sup> *Proc. I. R. E.—Waves and Electrons Section*, November 1947.

<sup>4</sup> *Proc. I. R. E.*, November 1947.

*Microwave Antenna Measurements.*<sup>5</sup> C. C. CUTLER, A. P. KING and W. E. KOCK. A description is given of the techniques involved in measuring the properties of microwave antennas. The measuring methods which are peculiar to these frequencies are discussed, and include the measurement of gain, beam width, minor lobes, wide-angle radiation, mutual coupling between antennas, phase, and polarization. The requirements of the antenna testing site are taken up, and components of a complete measuring system are briefly described.

*Microwave Converters.*<sup>6</sup> C. F. EDWARDS. Microwave converters using point-contact silicon rectifiers as the nonlinear element are discussed, with particular emphasis on the design of the networks connecting the rectifier to the input and output terminals. Several converters which have been developed during recent years for use at wavelengths between 1 and 30 centimeters are described, and some of the effects of the impedance-versus-frequency characteristics of the networks on the converter performance are discussed.

*Recent Developments in Relays.*<sup>7</sup> *Glass-Enclosed Reed Relay*, W. B. ELLWOOD; *Mercury Contact Relays*, J. T. L. BROWN and C. E. POLLARD. Relays which combine high-speed and great uniformity of performance over long periods of time are required for some uses in the telephone plant. The relays described possess these qualities to an unusual degree. Detailed description is limited to two types, each typical of a generic family in which the principles involved apply to all.

These relays are based on the philosophy that a motor element (any device for conversion of electromagnetic to mechanical energy), which is efficient and magnetically and elastically stable and operates contacts sealed in a proper atmosphere free from dirt and film, will give reliable performance if the contact load is engineered to the capacity of the contact. The relays require no maintenance beyond unit replacement, for there is no possibility of a change in adjustment after assembly is completed.

In one form the contact is provided for by metal in solid form, while in the other a mercury film supported on solid metal surfaces provides the contacting medium. The mercury at the contacting surfaces is replenished continuously through a capillary path from a mercury reservoir below the contact.

*An Adjustable Wave-Guide Phase Changer.*<sup>8</sup> A. GARDNER FOX. A very interesting and useful component of the wave-guide art is the differential phase-shift section, wherein dominant waves of one polarization are caused to travel through a section of wave guide at a different velocity than waves

<sup>5</sup> *Proc. I. R. E.*, December 1947.

<sup>6</sup> *Proc. I. R. E.*, November 1947.

<sup>7</sup> *Elec. Engg.*, November 1947.

<sup>8</sup> *Proc. I. R. E.*, December 1947.

polarized at right angles to the first. Particularly useful are the  $\Delta 90$ -degree and  $\Delta 180$ -degree differential phase-shift sections which produce differential delays between the two polarizations of 90 degrees and 180 degrees, respectively. The properties of these sections are discussed, and it is shown how they may be combined to form a phase changer which will transmit substantially 100 per cent of the incident power with a phase which is readily adjustable. Several different methods of building these sections are finally described.

*Considerations in the Design of a Radar Intermediate-Frequency Amplifier.*<sup>9</sup> ANDREW L. HOPPER and STEWART E. MILLER. The intermediate-frequency amplifier of a microwave radar receiver is commonly required to provide approximately 100 decibels amplification in a bandwidth of 1 to 10 megacycles, centered at frequencies in the 30- and 60-megacycle regions. Meeting such requirements involves the use of five to ten amplifier stages of the highest efficiency that can be suited to production methods. In addition, the noise figure of the radar intermediate-frequency amplifier is a significant contributor to the over-all radar receiver noise figure, and must therefore be maintained at an absolute minimum. By examining a particular intermediate-frequency-amplifier design (one providing an over-all bandwidth of 10 megacycles centered at 60 or 100 megacycles), this paper discusses qualitatively the theoretical problems involved in such a design and gives data of practical importance to the engineer attempting to build a similar amplifier. Measured characteristics of approximately fifty amplifiers are summarized to illustrate the end results achieved.

*Historical Note on the Rate of a Moving Atomic Clock.*<sup>10</sup> HERBERT E. IVES. The history of the idea of variation of frequency with velocity is followed through Goigt, Larmor, Lorentz, and Einstein. The Michelson-Morley experiment is explainable by any contraction of dimensions in the ratio  $(1 - v^2/c^2)^{1/2}:1$  along and transverse to the direction of motion. To each contraction corresponds a different value of frequency change. The theoretical speculations pointing to the relation  $v_m = v_0(1 - v^2/c^2)^{1/2}$  are discussed, together with the significance of the experimental test by means of canal rays.

*New Low-Coefficient Synthetic Piezoelectric Crystals for Use in Filters and Oscillators.*<sup>11</sup> W. P. MASON. Two crystals of the monoclinic sphenoidal class have been found which have modes of vibration with zero temperature coefficients of frequency, high electromechanical coupling constants, and high  $Q$ 's or low dissipation. These properties make it appear probable that such crystals may have a considerable use in filters and oscillators as a sub-

<sup>9</sup> *Proc. I. R. E.*, November 1947.

<sup>10</sup> *Jour. Opt. Soc. Amer.*, October 1947.

<sup>11</sup> *Proc. I. R. E.*, October 1947.

stitute for quartz, which is difficult to obtain in large sizes. These crystals are ethylene diamine tartrate (EDT) having the chemical formula  $C_6H_{14}N_2O_6$ , and di-potassium tartrate (DKT) having the formula  $K_2C_4H_4O_6 - \frac{1}{2} H_2O$ .

The paper describes the properties of EDT, since this crystal has been found more advantageous than DKT. The 13 elastic constants, the 8 piezoelectric constants, and the 4 dielectric constants have been measured over a temperature range, and from these measurements the regions of low temperature coefficients and high electromechanical coupling have been located. Six low-temperature-coefficient cuts have been discovered and the properties of these cuts are given. These cuts are being applied in the crystal channel filters of the long-distance telephone system, and may be applied to the control of oscillators.

*Multi-Channel Carrier Telegraph.*<sup>12</sup> A. L. MATTE. Discussion of a carrier telegraph system, adapted specifically to railway requirements, to meet the needs for high-quality line transmission.

*Reflex Oscillators for Radar System.*<sup>13</sup> J. O. McNALLY and W. G. SHEPHERD. The advantages to be gained in the operation of radar systems at very high frequencies have led to the use of frequencies of several thousand megacycles. Operation at these frequencies has imposed serious problems in obtaining suitable tube behavior. Because of the difficulty in obtaining amplification at the transmission frequency, the r.f. section of the usual radar receiver consists of a crystal converter driven by a beating oscillator and operating directly into an i.f. amplifier. Since the midband frequency of the latter has commonly been either 30 or 60 Mc., it has been necessary to provide beating oscillators operating at frequencies differing from those of the transmitter by only a few per cent.

For radar systems intended to operate at approximately 3000 Mc., which were under development in the early days of the war, it was found that triodes then available gave unsatisfactory performance. Attention shifted to the possibility of using velocity-modulated tubes, and the particular form known as the reflex oscillator came into general use.

In this paper the requirements on beating-oscillator tubes for radar systems are discussed, and the design features which have made the reflex oscillator eminently satisfactory in this application are pointed out. Problems encountered in such oscillators are outlined, and the solution in a number of cases is indicated. In some instances military requirements and expediency were in conflict with the optimum performance, and hence certain compromises were necessary.

<sup>12</sup> *Railway Signaling*, December 1947.

<sup>13</sup> *Proc. I. R. E.*, December 1947.

*Space-Charge and Transit-Time Effects on Signal and Noise in Microwave Tetrodes.*<sup>14</sup> L. C. PETERSON. Signal and noise in microwave tetrodes are discussed with particular emphasis on their behavior as space-charge conditions are varied in the grid-screen, or drift, region. The analysis assumes that the electron-stream velocity is single-valued. For particular conditions the noise figure may be substantially improved by increasing the space-charge density in the grid-screen region until an entering electron encounters a field of a certain magnitude. The noise reduction is largely due to the cancellation in the output of the noise produced by the random cathode emission. The method of noise reduction described is applicable only when the transit angles of both input and drift regions are fairly long.

In a forthcoming paper, H. V. Neher describes experimental results which broadly agree with the theory.

*"Cloverleaf" Antenna for F. M. Broadcasting.*<sup>15</sup> PHILLIP H. SMITH. The radiation requirements and general design considerations for transmitting antennas suitable for f.m. broadcasting are briefly discussed, and an explanation of the design and operation of the arrangement of radiating elements and associated feed system employed in the "cloverleaf" antenna is given. Both calculated and measured data are included, showing field-intensity distribution, gain, impedance-frequency characteristics, etc. Design features which are discussed include a simple coaxial impedance-matching transformer developed initially for microwave application, and the method and facilities provided for the removal of sleet.

*Hybrid Circuits for Microwaves.*<sup>16</sup> W. A. TYRRELL. The fundamental behavior of hybrid circuits is reviewed and discussed, largely in terms of reciprocity relationships. The phase properties of simple wave-guide tee junctions are briefly considered. Two kinds of hybrid circuits are then described, the one involving a ring or loop of transmission line, the other relying upon the symmetry properties of certain four-arm junctions. The description is centered about wave-guide structures for microwaves, but the principles may also be applied to other kinds of transmission lines for other frequency ranges. Experimental verification is provided, and some of the important applications are outlined.

<sup>14</sup> *Proc. I. R. E.*, November 1947.

<sup>15</sup> *Proc. I. R. E.—Waves and Electrons Section*, December 1947.

<sup>16</sup> *Proc. I. R. E.*, November 1947.